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NOTES ON THE OSTEOLOGY AND SYSTEMATIC POSITION OF DINICTIS FELINA, LEIDY.

BY W. B. SCOTT.

The problem of the origin of the *Felidæ* and of their relations to the other families of Carnivora is one of such obscurity, that any information upon the subject, however slight, cannot fail to be of importance. Of all the American felines (or Pseudailuroids, as the case may be) the genus *Dinictis* is probably the most primitive and therefore the one best adapted to throw light upon the line of descent through which the group has passed. A considerable amount of undescribed material of this curious genus has come into my hands, among which there is an almost complete hind leg and foot belonging to the Princeton Museum (No. 10,035), which has led to the preparation of these notes.

THE SKULL.

The skull has already been described by Dr. Leidy (No. 8[1], pp. 64–65), but additional material enables me to supplement his account. The most important of the specimens to be described is a fine skull in the Academy's Museum, the base of which exhibits some most interesting characters.

As in the primitive carnivores generally, the cranium is very long and narrow and is sharply constricted some distance behind the orbits, which marks the anterior limits of the cerebral hemispheres. Posteriorly the cranium is broadest and tapers forwards more regularly and more rapidly than in the *Viverridæ* and the constriction above mentioned is further back of the orbits than in that family, occupying the same relative position as in *Daphænus*[2] and other primitive cynoids. Another factor which is of importance in the construction of the cranium is the elongation of the posterior portion of it, that part lying behind the mastoid processes. This region in *Dinictis*, as in the viverrines, *Cynodictis*,[2] and in most creodonts, is very long. In spite, therefore, of the greatly elongated cranium, including in that term the region behind the anterior rim of the orbit; the space allotted to the cerebral hemispheres is comparatively short, while the cavities for the hind-brain and the olfactory lobes are long. The face in advance of the orbits is much contracted.

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[1] See list of Authors at end of paper.

[2] The American cynoids of the White River and John Day epochs, which Cope has called *Galecynus* and Leidy has referred to *Amphicyon*, are for the most part more nearly like the European *Cynodictis*, under which name they are referred to here, though a careful comparison would not improbably show them to be distinct. The White River dogs with 3 upper molars are quite different from the true *Amphicyons*, and for these the name originally given them by Leidy, *Daphænus*, should be revived.

The upper contour of the cranium slopes sharply downwards and backwards from the highest point of the skull just behind the orbits, while that of the face slopes downwards and forwards from the same point, the two meeting in an open V. Of course at the point of meeting the skull is disproportionately deep, while the muzzle, and especially the occiput, is low. This gives the skull of *Dinictis felina* a very characteristic physiognomy and is an exaggeration of the arrangement found in *Hoplophoneus* and others of the *Nimravidæ*, but in the John Day species, *D. cyclops*, the contour is very different.

The premaxillaries have well developed alveolar portions, which, however, form a nearly straight transverse line and project but little in advance of the canines; the ascending ramus is very long and nearly vertical, its upper portion sloping backwards less than in the viverrines and further removed from the frontals than in that family. The maxilla has a high and short (antero-posteriorly) preorbital portion which joins the frontal by a short straight suture. The suborbital part of the maxilla exceeds the preorbital in length more than in the cats and very much more than in *Viverra*, as the orbit is placed far forward. The frontals are strongly inclined upwards and backwards and appear to be very decidedly shorter than in the cats; anteriorly they together form a notch to receive the ends of the nasals, but the fronto-nasal process is very short and more obtuse than in the cats, its maxillary and nasal edges forming a right angle. The nasals are longer than in the cats, but otherwise very much like them. The lachrymal is small and does not extend at all upon the face, as it does in the creodonts, and just within the edge of the orbit it is pierced by two foramina.

The parietals, so far as the great fissuring of the specimens will allow of a determination, seem to be much longer than in the cats and to exclude the frontals from all share in roofing the cerebral hemispheres. At all events the very long sagittal crest runs to a point in advance of the post-orbital constriction, from which point the supraciliary ridges diverge rapidly and pass outwards in bold curves to the short post-orbital processes of the frontals. Besides being long the parietals are deep vertically, extending far down on the sides of the cranium.

The squamosal is rather low, but long from before backwards; the root of the zygomatic process projects downwards below the basicranial axis much more strongly than in the cats and civets, but not to the same degree as in *Hoplophoneus*, where it forms a peculiar and conspicuous, pedicel. The glenoid cavity is thoroughly feline in appearance, owing to the strong development of the preglenoid ridge. The zygomatic arches are very long, compressed and quite heavy, though they do not arch out from the sides of the skull so strongly as in the true cats. The post-orbital process of the jugal is but feebly developed. Owing to the strong downward

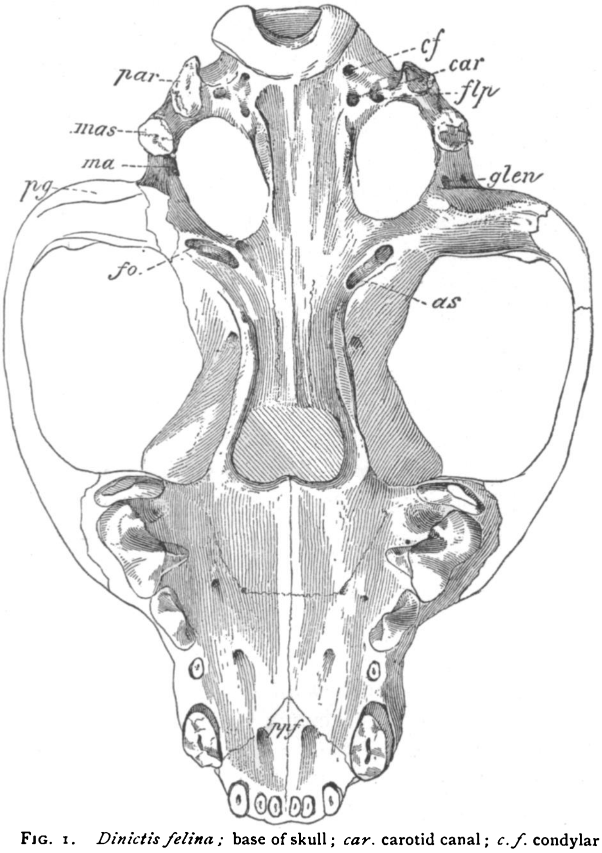


FIG. 1. *Dinictis felina*; base of skull; *car.* carotid canal; *c.f.* condylar foramen; *f. l. p.* foramen lacerum posterius; *glen.* glenoid foramen; *f. o.* foramen ovale; *as.* hinder opening of alisphenoid canal; *p. p. f.* posterior palatine foramina; *p. g.* post-glenoid process; *mas.* mastoid process; *par.* paroccipital process; *m. a.* external auditory meatus.

projection of the mastoid processes and their anterior position, the distance between these and the post-glenoid processes is very short and forms a deep narrow notch, which lends to this region of the skull an appearance very different from the corresponding part in the cats and civets.

The occiput is low, and very broad at the base, but narrowing rapidly upwards; it is exceedingly convex, in correspondence with the very advanced position of the mastoids, and consequently much of the occipital surface is visible in the side view of the skull. Above the foramen magnum there is a strong convexity which covers the prominent vermis of the cerebellum. The paroccipital processes are short, almost rudimentary in fact; they project backwards and are separated by a considerable interval from the auditory bullæ, as in the mustelines. The mastoid processes are heavy, prominent and not in contact with the bullæ.

Notwithstanding the angle made by the upper contour of the face and cranium, the cranio-facial axis is straight. The base of the cranium is broad and the glenoid cavities of the two sides widely separated from each other, which results in a somewhat unusual arrangement of the foramina. The basi-occipital is not so broad as in the *Viverridæ,* and has sharp prominent edges which abut against the sides cf the tympanic bullæ and so give the bone a deeply concave shape from side to side. The bullæ are very large and were almost certainly divided by an internal septum into two chambers, though whether the chambers are situated one behind the other, as in the *Viverridæ,* or one internal to the other. as in the *Felidæ,* cannot be determined from the material at command, though the external shape is rather feline. Though the opening into the bulla is quite far removed from the surface, there is no tubular meatus auditorius other than that formed by the notch between the mastoid and post-glenoid processes. The relation of the bullæ to the mastoid and paroccipital processes recalls that which is found in the bears, save that in *Dinictis* the latter processes are so small.

The posterior nares are very long, owing to the fact that the bony palate is not carried back of the molars. In front the opening is broad and its anterior edge is formed by two emarginations of the palatines, separated by a short median spine or angle; in the hinder part of their course the walls of the nares are constricted, giving them a characteristic appearance. The hamular processes of the pterygoids are decidedly more feline than viverrine both in shape and position, being much further in advance of the glenoid cavity than in the latter animals. The palatines are short and broad, the maxillo-palatine suture being opposite the interval between the 3rd and 4th premolars, and in general shape they resemble those of the cats. The hard palate is very broad behind, and following the oblique position of the molar series, it narrows rapidly forward, though it never becomes very narrow on account of the abruptly truncated muzzle. The palatine processes of the premaxillaries are well developed. The whole palatine region has a decidedly feline appearance, though *Cryptoprocta* exhibits an approach to it, as it does in so many other respects as well.

The mandible is peculiar and is in most respects very closely like that of *Hoplophoneus*, but the condyle is more elevated above the line of the molars and the coronoid process is much higher; the latter has a less antero-posterior extent, is straight and less recurved than is usual in the felines. The masseteric fossa is very deep and extends forward beneath $\overline{\text{m. 2.}}$ The horizontal ramus is compressed and rather slender and shallow; its lower border is nearly straight until the front end is nearly reached, when it dips downwards to form the flanges for the protection of the great upper canines, though these flanges are not so long as in *Hoplophoneus*, in correspondence with the less development of the tusks. The chin is slightly concave and abruptly truncate, as in the sabre-tooths generally, and forms a right angle with the side of the ramus; the symphysis is short and nearly vertical.

Foramina. These present a curious assemblage, being anything but "ailuroid" in arrangement. The incisive foramina call for no description, being much like those of the cats in size and position. The posterior palatine foramina resemble those of the civets in so far that they are in the maxillaries and not in the palatines, but they are placed much further back than in that group, being opposite the anterior edge of pm. 3. There is an alisphenoid canal, the posterior opening of which is nearer to the very large foramen ovale than in the viverrines and indeed is enclosed in a common groove with it. The latter is placed unusually far from the median line and is separated by a prominent ridge from the eustachian canal and the foramen lacerum medium, which occupy the ordinary position close to the antero-internal angle of the bulla. There is a large and distinct carotid foramen which is well separated from the foramen lacerum posterius. The condylar foramen is also entirely separated from the latter, and there is no ridge running inwards from the paroccipital process. There are also very large glenoid foramina. There is a single large post-parietal foramen on each side of the sagittal crest. The infra-orbital foramen is placed very close to the orbit, from which it is separated only by a narrow bridge of bone; it lies above pm. 3.

The arrangement of foramina in *Dinictis* is thus seen to be very much the same as that described by Cope in *Archælurus* and others of the *Nimravidæ* (No. 2. p. 955), but no living carnivore presents such an assemblage of characters in the *basis cranii*. These primitive cats seem to show conclusively that the construction of the base of the cranium has not the taxonomic value attributed to it by Flower (No. 5) an opinion which Schlosser (No. 14, p. 233) has reached on quite different grounds. The *basis cranii* of *Dinictis* is perhaps on the whole more cynoid than anything else, though ailuroid and even arctoid features occur. We shall return later to a discussion of this question.

The *brain* of *Dinictis* is unknown, but that of *Hoplophoneus*, a nearly allied genus, has been described and figured by Bruce (No. 1, p. 42, Pl. vii, fig. 8). This is distinctly feline in character, though as would naturally be expected, the convolutions are simpler and less winding; it bears obvious resemblance to the brain of *Pseudælurus* which Gervais has figured (No. 7, Pl. 6, fig. 6) and which, as that writer has pointed out, has certain affinities with the brain of *Cryptoprocta* and the viverrines.

THE DENTITION.

The dental formula of *Dinictis* is I $\frac{3}{3}$ C $\frac{1}{1}$ Pm. $\frac{3}{3}$ M $\frac{1}{2}$, which, as Leidy has observed, is the same as that of most mustelines, and also occurs in *Ælurogale.*

Upper Jaw. The incisors are in general cat-like and form a straight, transversely directed row, separated by considerable diastemata from the canines. The external incisor is the largest of the series and has a long, acute, conical and somewhat recurved crown, except for its smaller size, very similar to that of *Hoplophoneus.* As in that genus, there is no cingulum, such as occurs in the external incisor of the cats. The median incisor is much smaller than the outer one and has a simple pointed crown without cingulum. Only the fang of the inner incisor is preserved, but this shows that the tooth was still smaller and more compressed than the median one. In *Hoplophoneus* the incisors are all much larger, all have similar crowns, and are separated by wider spaces from each other and from the canines.

The upper canines of *Dinictis* are compressed and elongated tusks of narrow oval section; they are, however, shorter and less compressed than in *Hoplophoneus.*

The most anterior premolar (pm. 2) is exceedingly small, much more reduced than in *Cryptoprocta;* it has a compressed conical crown with a sharp posterior cutting edge which is finely serrate, and a very minute posterior basal cusp; it is implanted by two fangs. Pm. 3 is a large and well developed tooth; it is much higher and more compressed than in the *Felidæ,* and the large posterior cusp is single, not double as in that family. This tooth resembles much the corresponding one in *Cryptoprocta,* but the principal cusp is more compressed and has a greater antero-posterior extent. The sectorial (pm. 4) is more canine than either feline or viverrine and differs from pm. 3, only in its greater size, the greater proportional development of the heel and the presence of the inner cusp. This tooth is very like the sectorial of *Cynodictis,* exhibiting only the following differences: (1) the anterior cusp is more flattened; (2) the heel is longer and higher; (3) where the two come together there is a deeper fossa, such as is found in cats; (4) the inner cusp is less reduced, though smaller than in *Cryptoprocta* and very much smaller than in the *Viverridæ* generally. Of the anterior basal cusp which is so characteristic of the cats and which appears in *Cryptoprocta* and to a certain extent in other viverrines, there is not a trace. The sectorial of *Hoplophoneus* is decidedly more cat-like than that of *Dinictis,* as is shown in the better development of the sectorial blade and in the appearance of a small antero-external cusp.

The single upper molar of *Dinictis* is very much better developed than in the cats, or *Cryptoprocta,* or even than in *Hoplophoneus,* but is much more reduced than in the *Viverridæ* generally; it is not at all overlapped or concealed by the sectorial, being plainly visible from the side. The construction shows clearly its derivation from the tritubercular pattern of *Cynodictis,* but the length of the tooth from before backwards has been greatly reduced, so that the two outer tubercles have come to stand in nearly the same transverse line, while the inner cusp has extended far internally. The tooth is implanted by three fangs. In *Hoplophoneus* the separation into three cusps is very obscure.

Lower Jaw. The crowns of the lower incisors are broken away in all the specimens I have had the opportunity of examining, but the fangs show that, as in the upper jaw, the outer teeth are the largest of the series, and that, as in the cats, the lower incisors form a straight row, the second one not being pushed back as is so commonly the case among the Carnivora.

In correspondence with the lesser development of the upper tusks, the lower canine is larger than in *Hoplophoneus.* The crown is high, conical and somewhat recurved. The most anterior premolar (pm. 2) is very small and more reduced than in *Cryptoprocta;* it consists of a simple compressed cone implanted by two fangs. Pm. 3 is proportionally larger, higher, more acute and more compressed than in the cats; it is composed of a principal conical cusp, with small anterior and posterior cingular cusps. Pm. 4 is almost exactly like pm. 3 except that it is somewhat larger, and that the accessory cusps are more conspicuous. Both of these teeth differ from the corresponding ones of *Felis* not only in their relatively larger size and smaller transverse diameter, but also in the absence of the posterior cingulum. In *Cryptoprocta* the principal cusp is more slender and pointed and the cingulum is better developed, especially on pm. 4, than in *Dinictis.* In *Proailurus* these teeth are much like those of *Cryptoprocta.*

The first or sectorial molar is very feline in appearance, though with very obvious signs of its derivation from the tuberculo-sectorial type. The anterior cusp is formed just as in the cats, but the posterior cusp is higher and less flattened and more distinctly angulate between the lateral and posterior surfaces. In many specimens there is a small but perfectly distinct postero-internal cusp, which thus completes the primitive triangle of the tuberculo-sectorial molar, and in these specimens the tooth is almost a reproduc. tion of the lower sectorial of *Proailurus,* as figured by Filhol (No. 4, Pl. 2, fig. 2). But in *Dinictis* this cusp is evidently on the point of disappearing, as in some specimens it is present only on one side, in others hardly visible at all. The talon is also very small and has a sharp cutting edge, with no trace of accessory tubercles. The second molar is very much reduced and has a small oval crown; the fang, though single, is elongate and obviously formed by the coalescence of two, as is shown by the median groove which runs down the inner face and by a partial division of the alveolus. The tooth is much less reduced than in *Proailurus.*

The dentition of *Dinictis*, like the skull, irresistibly suggests relationship with the cats, and yet it still exhibits many important primitive characters, of which may be mentioned the number of the teeth, the large size of the upper molar and the presence of the inferior tubercular; the presence of a heel and of the posterior-internal cusp on the lower sectorial and the absence of the anterior basal cusp from the upper sectorial. In these respects *Dinictis* departs from the feline type and approximates the canine-viverrine group.

MEASUREMENTS.

	M.
Total length of skull (condyles to premaxillaries),	·154
Length of cranium (to anterior rim of orbit),	·108
Length of face,	·046
Distance from anterior rim of orbit to post-orbital constriction,	·050
Length of bony palate,	·069
Breadth of bony palate (posterior edge),	·072
Breadth of bony palate between canines,	·026
Distance between foramen magnum and line of post-glenoid processes,	·033
Distance between foramen magnum and line of mastoid processes,	·0195
Length first four cervical vertebræ,	·075
Length of mandible, from the condyle,	·119
(Second Specimen, Princeton Mus., No. 10,012.)	
Upper incisor series, transverse breadth,	·029
Third upper incisor, transverse diameter,	·0045
Third upper incisor, fore and aft diameter,	·005
Second upper incisor, transverse diameter,	·003
Second upper incisor, fore and aft diameter,	·003
Upper canine, transverse diameter,	·008
Upper canine, fore and aft diameter,	·012
Length upper molar series,	·049
Length pm. 2,	·0055
Length pm. 3,	·014
Length pm. 4,	·019
Length m. 1,	·006
Transverse diameter m. 1,	·015
Lower incisor series, transverse breadth,	·016
Third lower incisor, fore and aft diameter,	·005

Third lower incisor, transverse diameter,	·0035
Lower canine, fore and aft diameter,	·008
Lower canine, transverse diameter,	·006
Length lower molar series,	·052
Length pm. 2,	·006
Length pm. 3,	·012
Length pm. 4,	·0145
Length m. 1,	·0185
Length m. 2,	.006

VERTEBRÆ.

Attached to the Academy's specimen of the skull of *Dinictis*, which has been described above, are the four anterior cervical vertebræ, which are decidedly feline in character, and resemble those of the John Day *Nimravidæ* described and figured by Cope. The atlas is badly broken and only the slender inferior arch and deep anterior cotyli can be certainly made out. The parts preserved, however, agree closely with the atlas of *Hoplophoneus,* which in its turn is most like that of *Cryptoprocta.* The transverse processes are much more widely extended than in the *Viverridæ* generally, and there is, as in that family, a foramen in the anterior edge of the transverse process (centroido-diapophysial, Albrecht) which in the cats is represented by a deep notch. The axis, so far as preserved, agrees rather better with that of *Cryptoprocta* than that of *Hoplophoneus;* the odontoid process is a very long and slender peg, while in *Hoplophoneus* it is broader and more depressed than is usual in the carnivores. The centrum is depressed, slightly opisthocœlous and provided with a small hypapophysial keel; the atlanteal facets are extended transversely, but have a small vertical diameter and are not emarginated by the neural canal. The posterior face of the centrum is set obliquely to the long axis, as are the faces of the succeeding vertebræ, though not to the same extent as in the large cats. The transverse processes are slender and shorter than in *Cryptoprocta* and the anterior opening of the vertebrarterial canal is placed much further forward than in that genus. The neural arch is high and narrow and not obstructed behind by opisthapophyses, as in the recent felines. The third and fourth cervicals have rather short and quite broad centra, with hardly any indications of hypapophysial keels. They are slightly opisthocœlous and the articular faces are somewhat oblique. The third has the neural spine represented by a very low ridge, and as in the felines there are opisthapophyses; the transverse processes are slender and the pleurapophysial plates but little developed. The hind part of the neural arch of the fourth is broken away so that nothing can be determined as to the character of the spine and the opisthapophyses; the pleurapophysial plate is much better developed than on the third vertebra.

FORE-LIMB.

This member is but very scantily represented in the collections, the only portions of it which I have seen being fragments of the humerus and radius. Fortunately there can be no doubt as to the reference of these specimens, as they were found associated with a skull (No. 10,012 of the Princeton Museum). The humerus is too much mutilated for description, further than to say that this bone is much stouter than the femur would lead one to expect; the supinator ridge is very prominent and runs far up the shaft.

The radius is distinctly feline in character. The proximal end is formed by a small disc-like head with a concave facet for the capitellum of the humerus; the concavity is not quite so deep and its margin not so even as in the cats, being notched in the middle of the front edge, which edge is thus given a sigmoid curve. The head does not project inwardly beyond the line of the shaft, as is so markedly the case in the lion. The articular surface for the ulna forms a narrow band which extends around two-thirds of the circumference of the head, considerably more than in the lion and indicating very complete powers of pronation and supination. Distal to the head the shaft gradually contracts and becomes irregularly oval in section. The lower part of the shaft is quite broad, thickened on the outer side and tapering to a thin edge on the inner; the distal end is somewhat rugose and narrower than the lower part of the shaft, the rugosities are much less prominent than in the recent forms. The facet for the scapho-lunar is broad towards the ulnar side and slightly concave in both directions, but suddenly becomes much narrower internally. There is a small facet on the external side for the distal end of the ulna.

It is interesting to note that the distal end of the radius in the Bridger creodont, *Miacis bathygnathus*, is very similar to that of *Dinictis*, but the carpal surface is somewhat differently shaped, and the styloid process less prominent.

The *pelvis* is rather more viverrine than feline in character, though with some points of resemblance to that of the *? Cynodictis* (*Galecynus*) *geismarianus* of Cope (No. 2, Pl. lxx*a*, fig. 10). The anterior end of the ilium is broken away, so that its length cannot be determined, but judging from the position of the sacral facet, it would seem to be somewhat shorter than the ischium. The neck is short, deep and thick and the anterior expansion does not greatly exceed the neck in breadth. The gluteal surface is not simply concave, as in *Felis*, but is divided by a sharp ridge into upper and lower concavities, of which the upper is the broader; this ridge also occurs in the *? Cynodictis* above mentioned and is faintly marked in *Viverra*. The acetabular border is short, but broad, rugose and prominent, and beneath it is a small antero-inferior tuberosity or spine, giving to this region a decided similarity to the pelvis of *Cryptoprocta*. Mivart says with regard to the pelvis of the viverrines: "There may be two prominences (each like an ilio-pectineal prominence)—one just preaxiad to the acetabulum, and the other placed a little more ventrally on the pelvic brim. These may both be found (at least sometimes) in *Cryptoprocta, Viverra, Crossarchus* and especially in *Suricata*." (No. 13, p. 473.) Very much the same statement will apply to *Dinictis*.

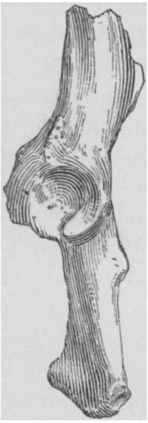


Fig. 2. *Dinictis felina*; left os innominatum.

The ischium is long, straight, slender and of trihedral section; the posterior portion is hardly at all everted, a striking difference from the condition seen in both *Felis* and *Canis*; the tuberosity is a mere thickening of the border and not at all projecting. The spine is represented by a slight convexity of the superior border, which ends abruptly behind, forming thus the lesser sacro-ischiadic notch. This notch is placed somewhat further behind the acetabulum than in *? Cynodictis* and occupies about the same position as in *Cryptoprocta*. The portion of the ischium which descends to form the symphysis is broken away, but was obviously slender and much compressed; the same may be said of the pubis.

The *femur* is long and slender and resembles that of many of the more primitive carnivores, such as *Amphicyon, Cynodictis, Crypto-*

procta, *Proailurus*, etc. The head, as in *Cryptoprocta* is presented more obliquely inwards and upwards than in the cats; it is very sharply constricted off from the neck and is evenly rounded, forming something more than a hemisphere, and shows a distinct pit for the round ligament. The great trochanter is massive and much extended from before backwards, but rising only slightly above the level of the head, and its upper edge is more regularly rounded than in the cats; the digital fossa is deep but of limited extent. The ridge connecting the head with the great trochanter is, as in *Proailurus*, more compressed than in *Cryptoprocta*. The second trochanter is quite prominent; a short curved rugose line runs from this point towards the lower end of the great trochanter. Of especial interest is the presence of a well developed third trochanter, which runs some distance down the shaft and is continued as an external linea aspera. The third trochanter appears to be universally present in the creodonts, it is also found in *Amphicyon* (Filhol, No. 4*a*, Pl. xiv, fig. 4, Pl. xv, fig. 5), *Cynodictis* (Schlosser, No. 14, p. 265), *Proailurus* (Filhol, No. 4, Pl. 5, fig. 3), and the figure given by Milne-Edwards and Grandidier (No. 11, Pl. 9, fig. 7) would seem to indicate its presence in *Cryptoprocta*, though the specimens which I have had the opportunity of examining did not possess it. It is further faintly indicated in certain of the *Procyonidæ* and *Viverridæ*, but no living carnivore exhibits it in any such degree of development, as is seen in *Dinictis*. In the latter the shaft is rather long and slender and quite strongly arched forward; the posterior surface is flattened, the anterior regularly curved from side to side. The lower portion of the shaft expands gradually to the condyles; the popliteal region is nearly smooth, showing no such rugosities for muscular attachment as occur in the larger cats; it is even less rugose than in *Cryptoprocta*. The condyles are of nearly equal size and are quite widely separated; above and to the side of each one is a small articular facet, apparently for sesamoid ossicles. The rotular trochlea is broad, shallow and symmetrical, giving to this region of the bone a very feline appearance.

The femur of *Nimravus* is quite different from that of *Dinictis;* the shaft is more slender and more decidedly curved; the condyles project more strongly backward, due, no doubt, to the digitigrade gait of this animal, while *Dinictis* was plantigrade, and the condyles

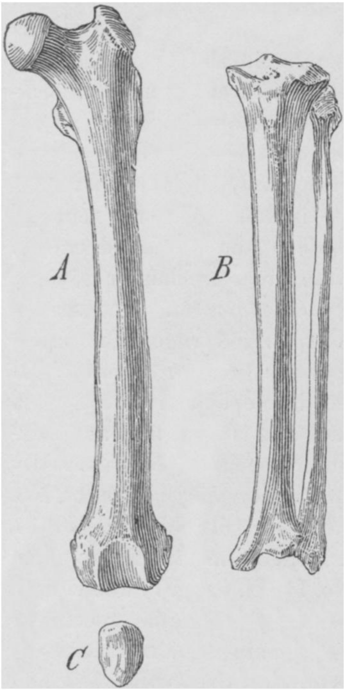


Fig. 3. *Dinictis felina;* A, left femur; B, left tibia and fibula; C, left patella.

are less equal in size; the trochlea is longer and more curved and the pits for the attachment of the crucial ligaments much more marked.

The *patella* of *Dinictis* is broad but quite thin from before backwards; its upper margin is abruptly rounded and the lower end pointed, giving it the shape of a flattened almond. The articular surface is somewhat concave from above downwards and even more slightly convex from side to side. The anterior surface and the sides are but little roughened, or rather faintly striate.

The *tibia* is considerably shorter than the femur; if we designate the length of the latter as 10, that of the tibia would be 8·4. In *Proailurus lemanensis* the length of the tibia on the same scale is 9·3, in *Cryptoprocta* 8·6, in *Paradoxurus* 10·4, in *Cynogale* 9·1, in *Viverra civetta* 9·2; it thus appears that in *Dinictis* the disproportion is unusually great. Seen from in front the tibia in this genus appears to be straight, as in *Cryptoprocta* and *Proailurus,* not having the lateral curvature which occurs in many viverrines, seen from the side, however, the tibia is strongly arched forward. The proximal end differs in some not unimportant respects from that of both *Cryptoprocta* and *Proailurus;* the condyles are more flattened and are almost in contact, instead of being separated by a considerable interval; the spine is very low; the cnemial crest is somewhat less prominent and does not descend so far upon the shaft; the posterior portion of the condyles is also less deflected than in *Cryptoprocta.* On the postero-external angle of the outer condyle there is a large, flat oval facet for the head of the fibula. In *Archælurus* the upper portion of the tibia is very similar to that of *Dinictis,* but the cnemial crest is more massive and the shaft deeper from before backwards, while the spine is higher. In *Dinictis,* as in *Archælurus,* there is a deep concavity in the posterior side, just below the head. The upper two-thirds of the shaft is trihedral, the lower portion is compressed and oval in section. The distal end is quite peculiar; it is less expanded transversely than in *Cryptoprocta;* the internal malleolus is long and very heavy and projects somewhat inward as well as downward, and the lower end is abruptly truncate. The sulcus for the tibial tendons is double, as in the felines, and the bounding ridges are continued to the end of the malleolus. The astragalar surface is much flattened and the intercondylar ridge is hardly indicated, being formed merely by the angle at which the two facets meet. This region of the tibia is strikingly different from the corresponding part in *Proailurus* (see Filhol, No. 4, Pl. 5, fig. 6) in which the groove for the astragalus is much more complete. On the other hand, it is very similar to the distal end of the tibia in *Archœlurus* (Cope, No. 2,Pl. lxxia, fig. 15*a*).

The *fibula* is comparatively well developed and very cat-like; the proximal end is considerably expanded from before backwards and at the same time thickened; it bears a large, oval and obliquely placed facet for the head of the tibia. The shape of this part of the bone is much like that seen in many viverrines. The shaft, though slender, is quite as strong proportionately as in the existing cats and civets, and is of an irregular trihedral shape, with a sharp *crista interossea.* The distal end is more expanded in both directions than the proximal and in shape resembles that of the cats; on its posterior border is a deep tendinal sulcus, and on the inner side is a large facet for the external face of the astragalus. The fibula is in contact with the tibia only at the proximal and distal ends, the shafts of the two bones being quite widely separated throughout their entire length.

THE PES.

The hind-foot is relatively long and slender and has many points of resemblance to that of *Cryptoprocta,* as well as important differences from that animal. The calcaneum is very like that of *Proailurus* and has considerable resemblance to the calcaneum of *Procyon.* The tuber is short and stout, with a moderately expanded free end, which is grooved by a tendinal sulcus; the posterior astragalar facet is large, regularly arched from before backwards and presenting decidedly more internally than superiorly, in this respect resembling *Proailurus* rather than *Procyon.* The sustentaculum is heavy and prominent and the articular facet is reflected over upon the posterior side; the cuboidal facet is oval and concave, and slopes from within outwards and downwards. The outer side of the distal end of the calcaneum shows a prominent process, which is as strongly developed in *Proailurus* and *Procyon*, and to a less degree in *Cryptoprocta* and *Amphicyon*. This process is most conspicuous in the plantigrade forms, though it is also present in such forms as the tiger.

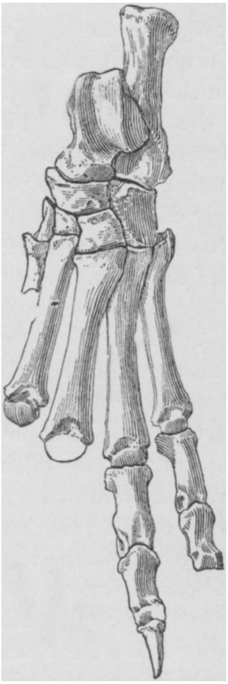


Fig. 4. *Dinictis felina*; left hind foot.

The astragalus of *Dinictis* is remarkable for its flatness, the intercondylar groove being hardly more than indicated; the outer condyle is much broader and somewhat higher than the inner and forms nearly a right angle with the very large and slightly concave external fibular surface; at its posterior (or superior) end the trochlea becomes exceedingly narrow and somewhat more deeply grooved; anteriorly it ends abruptly and is not continued down over the neck, as is the case in *Archælurus* and the tiger. The internal face of the astragalus is placed very obliquely and passes into the inner condyle by a gentle curve, quite different from the sharp ridge found in most recent carnivores, but very similar to the shape in *Archælurus*. The neck is very short and much less strongly deflected towards the tibial side than is usual in recent forms; the distal end is formed by the large convex head for the navicular, but upon the outer side there is a small, though distinct facet for the cuboid, a connection which rarely occurs in the recent carnivora, the bears and certain mustelines having it, however. Cope's figure of the astragalus of *Archælurus* (No. 2, Pl. lxxia, fig. 16b) seems to indicate its occurrence in that genus, and in all probability it will also be found in the White River species of *Cynodictis*, though in the *C. geismarianus* from the John Day horizon (Cope, No. 2, Pl. lxxa, fig. 9) it is not apparent. The facet for the sustentaculum is long and rather narrow, convex in front and concave behind, as it embraces the hinder edge of the sustentaculum; the external calcaneal facet is deeply concave from before backwards, and has an unusually oblique position in accordance with that of the corresponding surface on the calcaneum. The resemblance in the structure of the astragalus between *Dinictis* and *Archælurus* have been mentioned, but there are important differences, chief among which are that in the latter genus the inner condyle is continued almost to the navicular facet; the external side is curved outwardly very much more strongly and the facet for the sustentaculum is much smaller and further removed from the head.

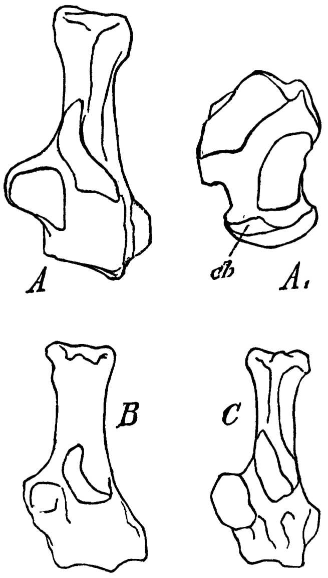


Fig. 5 A dorsal view of left calcaneum; A1, plantar view of left astragalus of *Dinictis felina*. In A1, *cb*. marks the facet for the cuboid. B, left calcaneum of *Proailurus*; C, of *Cryptoprocta*. B and C, after Filhol.

The *navicular* is rather unusually broad and of very simple construction; the proximal surface is taken up entirely by the deeply concave astragalar facet; on the external side there is a single narrow facet for the cuboid, and the distal side shows three facets for the cuneiforms, that for the ectocuneiform being much the largest, that for the entocuneiform is very obliquely placed, causing a great reduction of the height of the navicular upon the inner side.

The *cuboid* is a stout bone with large diameters in all three directions; the proximal surface, forming the facet for the calcaneum, is somewhat convex and slopes downwards and outwards from the internal side; internally to the calcaneal surface is a narrow and obliquely placed facet for the astragalus. The internal face of the cuboid shows a single small and nearly flat facet for the ectocuneiform. On the distal end there is a very large and slightly concave surface for the fourth metatarsal, and external to this very much narrower facet for the fifth metatarsal, which has an oblique position presenting outwards as well as downwards. The sulcus for the peroneal tendons upon the external side of the cuboid is very distinctly marked, though not nearly so deep as in *Procyon*.

The ectocuneiform is large, very broad on the dorsal side, especially distally and rapidly becoming narrower towards the plantar side, where from the proximal end is given off a stout knob-shaped process; on the internal side is a pair of small facets for the second metatarsal. The mesocuneiform resembles that of *Paradoxurus* in shape, having a very oblique facet for the navicular; the tibial side of the bone is much higher than the fibular and consequently the proximal edge slopes strongly downward and outward.

The entocuneiform is high and narrow, though of considerable depth; the proximal end rises sharply toward the plantar side, so that this diameter much exceeds that on the dorsal side. The facet for Mt. I is narrow and concave from before backwards. The entocuneiform descends considerably below the level of the mesocuneiform and abuts against the side of the second metatarsal.

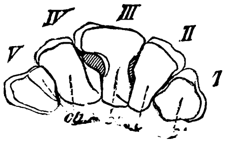


FIG 6. *Dinictis felina;* proximal ends of metatarsals, facets for the tarsals represented by c,' c," c,'" cb.

As compared with those of most of the existing *Felidæ*, the *metatarsals* of *Dinictis* are weak and slender and have a viverrine appearance. Only the proximal end of Mt. I is preserved and so its length cannot be determined, but the diameter of the shaft is relatively less reduced than in *Cryptoprocta*, and apparently the hallux bore about the same proportion to the other digits as in *Paradoxurus*. The head is convex from before backwards, concave from side to side, extending upwards and inwards, with a prominent rugose surface on the tibial side. Metatarsal II is rather short and quite slender; the head is wedge-shaped, becoming very narrow on the plantar side; the shaft is obscurely trihedral, flattened on the tibial and rounded on the other sides. Owing to the shortness of the mesocuneiform, Mt. II rises above the level of both I and III and is thus wedged in between the ecto- and entocuneiforms, an arrangement which is nearly universal among the fissipede carnivores. On the fibular side there is a slight depression for Mt. III, but this digit is not interlocked with its neighbors so firmly as the three external ones.

The third metatarsal is decidedly the heaviest, though not the longest of the series, and the proximal portion is especially broad; on the fibular side of this end is a very deep depression, into which fits a corresponding projection from Mt. IV. The facet for the ectocuneiform is very obliquely placed with reference to the long axis, rising strongly towards the fibular side, and has the ordinary feline arrangement, the two facets for Mt. IV being separated by a deep emargination, and the plantar side of the proximal end very much constricted. The shaft is very nearly straight. This bone articulates only with the ectocuneiform, being excluded from both the cuboid and the mesocuneiform, as both II and IV rise above it.

The fourth metatarsal is somewhat longer than No. III and decidedly more slender, though heavier than any of the others; it has a narrow convex head for the cuboid and is closely interlocked with III and V; on the tibial side is a prominence which fits into the pit on No. III and on the fibular side is a pit for the projection from No. V. The three outer digits are thus firmly interlocked by means of the metatarsals, No. II is less closely connected, but is securely held in place by being wedged between the ecto- and entocuneiforms. The shaft of Mt. IV is curved so that the distal end is deflected outwards, and is slightly twisted upon itself; seen from the dorsal side it seems to be attached only to the cuboid, but posteriorly has a small facet for the side of the ectocuneiform.

The fifth metatarsal is a little more slender than No. II and of about the same length, though it descends lower, owing to the lower level of its attachment to the cuboid as compared with that between the mesocuneiform and Mt. II; the cuboidal facet is very narrow and convex from before backwards, and above it rises the large, thickened and rugose external process; the shaft is curved both forward and inward, like that of No. IV. The distal ends of all the metatarsals show rounded hemispherical heads for the phalanges which are sharply constricted off from the shafts, and on the plantar side are sharp and prominent keels; just above these articular heads the shafts are expanded and have rugose processes for ligamentous attachment.

The metatarsals of *Dinictis* are not unlike those of *Cynodictis*, to the viverrine character of which Schlosser has called attention (No. 14, Taf. vi, fig. 18, 29), but in the former Mt. III is proportionately heaver and its proximal end overlaps No. IV more extensively, and the cuboidal facet of Mt. V is smaller. In *Ælurogale* (Schlosser, loc. cit. figs. 15 and 23) the metatarsals are very much heavier than in *Dinictis;* the head of Mt. II is less distinctly wedge-shaped, the head of No. IV is broader and shows an excavation on the tibal side which is not seen in *Dinictis*, while the projection from the head of Mt. V is much longer and more compressed. The shape of the fifth metatarsal is decidedly more feline in *Dinictis* than in *Ælurogale;* the shafts in the latter genus are also much straighter than in the former. The metatarsals of *Proailurus* seem

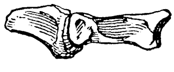


FIG. 7. *Dinictis felina;* median and ungual phalanges of IV digit seen from the fibular side.

to be considerably longer and more slender than those of *Dinictis* (Filhol No. 4, Pl. 4, figs. 1 and 5).

The *phalanges* of *Dinictis* are in general very much like those of *Cryptoprocta* but are proportionately stouter. Those of the proximal row are quite long, broad and strongly arched towards the dorsal side of the foot. Those of the second row are flatter and quite deeply excavated upon the fibular side of the distal end, in order to allow the retraction of the claws. This excavation is much more marked than in *Cryptoprocta* or in any of the *Viverridæ* which I have been able to examine. According to Mivart (No. 12, p. 157) the claws of *Prionodon* are almost as completely retractile as in the cats, as certainly seems to have been the case in *Dinictis*. The ungual phalanges are less strongly arched than in *Cryptoprocta;* they are short, very much compressed and not far from straight. In shape they are quite like the unguals of *Paradoxurus*, but the articular surface is of a different shape and the backwardly projecting process beneath this surface is much better developed, though not to the same degree as in the true cats. There is no trace of the bony lamina or hood which in the last-mentioned family is reflected over the base of the horny claw. This hood occurs in *Hoplophoneus* and probably also in the later *Nimravidæ* from the John Day, though we may infer that in this respect *Archælurus* agrees with *Dinictis*.

It will be seen from the foregoing description that the hind-leg and foot of *Dinictis* presents a very curious assemblage of characters. In some respects these characters are very primitive, as for example the large third trochanter on the femur, the greatly flattened ankle-joint, the articulation of the astragalus with the cuboid and the shape of the calcaneum. Indeed, I was at first misled into the belief that this specimen belonged to a creodont and accordingly referred it to *Hyænodon* (quoted in Cope, No. 3, p. 344) until material subsequently brought to light showed its true nature. Such a creodont-like tarsus associated with the highly differentiated dentition of *Dinictis* is certainly very remarkable. In general, the specimen before us has much resemblance to the corresponding parts of *Cryptoprocta* and other viverrines, as well as to *Cynodictis*, but at the same time there are points of approximation to the felines, of which the most important is perhaps the degree of retractility shown in the ungual phalanges, which seems to be equalled among the *Viverridæ* only by *Prionodon*.

MEASUREMENTS.

	M.
Femur, length,	·190
Femur, breadth, proximal end (head and great trochanter),	·038
Femur, breadth, distal end (greatest width of condyles),	·034
Tibia, length (including malleolus),	·168
Tibia, breadth, proximal end,	·034
Tibia, breadth, distal end,	·020
Calcaneum, length,	·043
Astragalus, length,	·027
Metatarsal I, breadth, proximal end,	·006
Metatarsal II, length,	·046
Metatarsal II, breadth, proximal end,	·006
Metatarsal III, length (?),	·051
Metatarsal III, breadth, proximal end,	·012
Metatarsal IV, length,	·053
Metatarsal IV, breadth, proximal end,	·006
Metatarsal V, length,	·0485
Metatarsal V, breadth, proximal end,	·008
First phalanx, fourth digit, length,	·022
Second phalanx, fourth digit, length,	·017
Third phalanx, fourth digit, length,	·015

THE SYSTEMATIC POSITION OF DINICTIS.

Before any systematic arrangement of the Carnivora can be accepted as final, it will be necessary to show the steps by which the various groups have diverged from the common stock. We are as yet by no means in a position to do this, and hence any classification of them at present can only be tentative. However, recent investigations throw some light upon the problem. It is obvious, in the first place, that the retention of primitive characters in any two groups of a series is no proof of any relationship nearer than that through the common ancestor of the entire series. Thus the presence of the alisphenoid canal, or the epicondylar foramen, cannot be employed as an indication of direct connection between two groups otherwise differing. Secondly, the *loss* of characters present in the ancestral form is no better indication of affinity, since we have abundant evidence that these suppressions take place independently. Examples of this are the reduction in the number of the teeth and digits, loss of the alisphenoid canal, the loss of the septum in the auditory bulla in the hyenas and mustelines, which no one supposes to be closely related. Although characters which belong to these two categories are by no means valueless, those which are derived from differentiations of a similar kind are much more important; that is to say, positive characters are of more value than negative ones. With these principles before us, we may proceed to the consideration of the question.

The arrangement of the fissipede Carnivora into Arctoidea, Cynoidea, and Aeluroidea proposed by Flower (No. 5), founded chiefly upon the characters of the basis cranii, has been very generally accepted among English speaking zoölogists, but as Schlosser (No. 14) remarks, it receives little support from paleontology, as in the various early fossil forms the characteristics are mingled in a very confusing way, and in a way not intelligible if Flower's arrangement be accepted. Schlosser regards the dogs and bears as being very closely related, while the mustelines, civets and hyenas are placed together as another series. The *Procyonidæ* (*Subursidæ*) "endlich stellen einen Formenkreis dar, der sich von den primitivsten Typen der Carnivoren, ausser im Zahnbau, fast gar nicht entfernt hat" (No. 14, p. 237). The cats, on the other hand, Schlosser believes to be widely separated from all others groups of Carnivora and to have been independently derived from creodonts, though admitting that as yet we know nothing of their history.

In most respects I regard these views as justified by paleontological evidence. Thus Gaudry (No. 6, ch. IX) and Lydekker (No. 9, p. 202; No. 10, p. 106) have satisfactorily shown the derivation of the bears from *Amphicyon* through *Dinocyon* and *Hyænarctos*. The connection between the viverrines and mustelines, though not so clear, is at all events very probable, as is shown by such forms as *Stenoplesictis*. Through the kindness of M. Filhol, I had an opportunity of examining a fine skull of *S. cayluxi* in his collection and found that it exhibited a remarkable combination of viverrine and musteline characters. The skull is like that of the civets in shape; the auditory bulla is divided by a septum and the separation into two chambers is plainly indicated by an external constriction; the bulla is in contact with the paroccipital process, though the latter is small and does not enclose the former as in a capsule, a striking difference from the viverrines. The condylar foramen is entirely free from the foramen lacerum posterius and perforates a ridge passing from the paroccipital process to the condyle. The alisphenoid canal, if present at all, is very minute, but the glenoid foramen is large and conspicuous. The combined viverrine and musteline features in the dentition of this and other genera have been fully described by Schlosser, and such forms certainly seem to indicate a close connection between the two families, while the relationship between the civets and hyenas is very generally admitted and need not be dwelt upon here.

Schlosser's scheme (No. 14, p. 238) does not indicate any near connection between the dogs and viverrines, which however, seems to be equally clear. The skull of the White River species, *? Cynodictis gracilis*, is interesting in this connection. In general character the skull is distinctly cynoid, but the long, narrow and sharply constricted cranium, the short, pointed face, and the slender mandible are very suggestive of the *Viverridæ*. The auditory bulla is marked by an external constriction as in most of the latter family, though I could not determine certainly the existence of a septum ; the bulla is not in contact at all with the paroccipital. The condylar foramen is much nearer to the foramen lacerum posterius than in *Canis* and occupies the same position as in *Viverra antiqua* from St. Gerand-le-Puy. The carotid canal is not enclosed in the foramen lacerum posterius. The upper true molars are more viverrine than canine in construction. The skeleton of this species is unfortunately not known at present, but Cope has called attention to the exceedingly viverrine character of the skeleton of the John Day species, *C.* (*Galecynus*) *geismarianus*. Schlosser likewise points out many viverrine features in the structure of the European *Cynodictis*, and it seems clear that, while *Cynodictis* should most probably be placed in the cynoid series, it stands very near to the point of division where the *Canidæ* and the *Viverridæ* diverged.

All of the carnivorous groups mentioned thus seem to come to a common point of origin and their early representatives agree quite closely in the characters of the skull and dentition. This primitive carnivorous skull may be thus described. The cranium is much elongated and very narrow; the elongation affecting chiefly the posterior part and the region between the orbits and the post-orbital constriction ; the parietal zone is very long and excludes the frontals from contact with the cerebral hemispheres and there is a very long and single sagittal crest; the face is comparatively short and the orbit is placed far forward; the mandible is slender and tapers rapidly forward, and the teeth are relatively small. As to the base of the cranium, this exhibits a combination of characters which are now found separately in the various groups of carnivores, though among the recent families the nearest approach to the primitive condition is found in the dogs. The auditory bulla is almost certainly divided by a septum, as is still to some degree the case in *Canis*, where the mode of development of the bulla is very like that which occurs in the cats; the alisphenoid canal and the post-glenoid foramen are present; the foramen lacerum posterius, carotid canal and condylar foramen are all distinct from each other; the mastoid and paroccipital processes are free from the bullæ and are placed far in front of the occipital condyles. It is usually taken for granted that a short face is always a secondary modification, but the history of several groups of mammals shows that this assumption is untenable in many cases. The primitive forms both of ungulates and carnivores from the Puerco and Wasatch all have short faces, very long and narrow crania, the orbits are placed far forward in the face, and the zygomatic arches are in consequence greatly elongated. The two factors which chiefly determine the modifications of the skull are the teeth and brain, and the principles which Rütimeyer has laid down with reference to the modifications of the ungulate skull apply equally well to the carnivores. In the later forms the orbit is shifted backwards and the zygomatic arches shortened, the parietal zone reduced, the frontal zone extended, the teeth are much enlarged and if their number is unreduced, the face becomes correspondingly elongated, as in the dogs, or it may become greatly shortened, accompanying the much reduced dentition, as in the cats. Comparing the dogs of the White River, John Day and Loup Fork epochs, the gradual elongation of the face becomes plain.

The derivation of the *Felidæ* offers problems of much greater difficulty than that of the other groups, and as we have already seen, Schlosser altogether rejects the view that they have any connection with the *Viverridæ*, and derives them independently from creodonts. According to Mivart the following characters are common to both families and the hyenas. (No. 12, pp. 137–8).

" 1. Bulla greatly dilated, rounded, smooth, thin-walled, with one exception, osseous, and almost always divided by a septum into two distinct portions.

2. Bony meatus short or with its inferior wall imperfectly ossified.

3. Paroccipital process applied to and, as it were, spread over the hinder part of the bulla.

4. Mastoid process never very salient, often obsolete.

5. Carotid canal small, sometimes very inconspicuous.
6. Condyloid fissure concealed.
7. Glenoid fissure extremely minute or absent.
8. Bone of penis generally small and irregularly shaped."

The same authority (pp. 144–5) gives the following skeletal and dental characters of the *Felidæ*:—

1. The muzzle is short as compared with the cranium.
2. The auditory bulla is much inflated, smooth and rounded, but hardly shows any external sign of division.
3. The bulla is more prominent towards its inner than towards its hinder border.
4. There is an almost complete bony septum between the two chambers of the bulla, which are one behind the other.
5. The bony meatus auditorius is short and neither produced anteriorly nor inferiorly, neither is it imperfectly ossified below.
6. There is no carotid foramen anywhere visible on the *basis cranii*.
7. There is no alisphenoid canal.
8. The palatine foramina are situated in the hinder half of the palate.
9. The post-orbital processes are more or less strongly developed, sometimes enclosing the orbits completely.
10. The paroccipital process projects only slightly as a rough tubercle beyond the bulla.
11. The mastoid is rather prominent.
12. The palate is very little or but moderately produced beyond the last molars.
13. The pterygoid fossa is very small.
14. Angle of mandible not greatly flattened beneath, and coronoid process high and inclined backwards.
15. There is a short pollex with a claw not, or hardly, reaching to distal end of metacarpal II.
16. The hallux is represented only by a rudimentary metatarsal bone.
17. The ungual phalanges are greatly arched with a wide lamina to shelter the base of the claw, and except in *Cynælurus* completely retractile.
18. Humerus with an epicondylar foramen.
19. Dorsal vertebræ 13 in number.
20. Bone of penis small.
21. $\underline{\text{P. 1}}$ and $\overline{\text{P. 2}}$ not developed.

22. There is no lower tubercular molar, no. $\underline{\text{M. 2}}$ and no. $\overline{\text{M. 2}}$.
23. $\underline{\text{M. 1}}$ is always very small and transversely extended.
24. The antero-external cusp of $\underline{\text{P. 4.}}$ is fairly developed, but much smaller than the two others.
25. $\overline{\text{M. 1}}$ has hardly any talon.
26. Proportionate length of limbs considerable.

To these characters should be added the following:

27. The postero-internal cusp of $\overline{\text{M. 1}}$ has disappeared.
28. The lower incisors form a straight row, the second one not being pushed backward out of line.
29. The front of the jaw is not tapered and the chin is abruptly rounded.
30. The metacarpals are very closely interlocked.
31. There are considerable remnants of the clavicles.

The *Viverridæ* are distinguished by the following characters, including *Cryptoprocta* in that family (Mivart. pp. 196–8):—

1. The auditory bulla (except in *Nandinia*) is ossified, much inflated and shows externally that it consists of two chambers, which may or may not be one behind the other.
2. The bony meatus auditorius is almost always short, and may have its anterior, posterior, or inferior margin most projecting; and it may be imperfectly ossified below.
3. The bulla is not more prominent towards its inner than towards its hinder border.
4. There are one or two carotid foramina on each side of the *basis cranii.*
5. There is an alisphenoid canal (except often in *Viverricula*).
6. The palatine foramina are situated in the anterior half of the palate.
7. The muzzle is large in proportion to the cranium.
8. The post-orbital processes are generally developed but rarely enclose the orbit.
9. Paroccipital process depending or not.
10. Mastoid prominent or not.
11. Palate not much, moderately, or much prolonged behind the molars.
12. Pterygoid fossa present or absent.
13. The coronoid process of the mandible is almost, if not quite always, less lofty relatively, and less backwardly produced than in the *Felidæ*.

14. There may or may not be a pollex; but in the large majority of species there is one.
15. There may or may not be a hallux; but in the large majority of species there is one.
16. The ungual phalanges may or may not be strongly arched, but there is not so wide a lamina of bone to shelter the base of the claw as in the *Felidæ*. They are hardly ever (except perhaps in *Poiana* and *Prionodon*) completely retractile, and often not at all so.
17. The humerus may be without epicondylar foramen.
18. The dorsal vertebræ never number more than fourteen.
19. The bone of the penis is small (except in *Cryptoprocta*).
20. $\underline{\text{P. 1}}$ is generally and $\overline{\text{P. 2}}$ constantly developed.
21. There is always an $\overline{\text{M. 2}}$ and generally an $\underline{\text{M. 2}}$.
22. $\underline{\text{M. 1}}$ is always present and generally large.
23. The antero-external cusp of $\underline{\text{P. 4}}$ is generally very small.
24. $\overline{\text{M. 1}}$ has almost always a considerable talon.
25. The limbs are short in proportion to the body.

To these we may add:—

26. Except in *Cryptoprocta*, the lower sectorial has a well developed postero-internal cusp.
27. The second lower incisor is pushed backwards out of the line of the others.
28. The mandibular rami are tapering.
29. The metacarpals are less complexly interlocked than in the cats.
30. There are no clavicles.

On comparing the description already given of *Dinictis* with the characteristic features of the cats and viverrines here set forth, it appears that, so far as the base of the cranium is concerned, these two groups agree together much more nearly than *Dinictis* does with either of them, the latter corresponding rather to the cynoids and very closely approximating the condition stated above as characteristic of the primitive stock of the Carnivora. In other respects the skull of *Dinictis* may fairly be said to be intermediate between the cats and viverrines in structure, but the shape of the mandible is peculiarly feline. The dentition exhibits the same intermediate characters, and though it approximates that of the cats in several important respects, it is distinctly less feline than is the dentition of *Cryptoprocta*. One very characteristic feature of the *Felidæ* is however shown in the dentition of *Dinictis*, namely, the fact that the crowns of the lower incisors form a continuous row and the second one is not forced out of line. The vertebræ of the genus before us are also rather feline, but with certain resemblances to the civets and especially to *Cryptoprocta*. The hind-limb has very little about it that reminds one of the cats, the most important resemblance being the degree of retractility shown by the claws, though this is shared by some civets. On the other hand both in its proportions and in its individual members the hind-limb and foot of *Dinictis* approximates closely the corresponding parts of many of the *Viverridæ*, though with certain features which are more primitive than occur in any living member of that family, for example, the well developed third trochanter of the femur, the very flat ankle joint and the articulation of the cuboid with the astragalus. And it further seems clear that the numerous viverrine characters are not the result of independent development, or "convergence."

In a former publication (No. 16, p. 153), I referred *Dinictis* to the *Cryptoproctidæ*; but since that account was written, I have had an opportunity to study specimens of the Madagascar genus, which have led me to agree with Mivart in referring this genus to the *Viverridæ*, to which *Dinictis* manifestly does not belong. The *Nimravidæ*, alone remain, and the characters of the base of the skull are so exactly like those of *Dinictis*, that in spite of differences in the feet, I feel constrained to follow Cope's example and place the White River genus in that family, of which it, probably, together with *Archælurus*, will form the more primitive section.

Comparing the *Nimravidæ* with the *Felidæ* and *Viverridæ*, we reach the following results:—

1. The muzzle is short as compared with the cranium.
2. The auditory bulla is inflated, but (in the genera in which this region is known) shows no external sign of division.
3. The bulla is more prominent towards its inner than towards its hinder border.
4. There is, probably, an almost complete bony septum between the chambers.
5. The bony meatus is not produced nor imperfectly ossified below.
6. There is a distinct carotid foramen.
7. There is an alisphenoid canal.
8. The palatine foramina are situated about midway in the palate.

9. The post-orbital processes are generally very small, and never enclose the orbit behind.

10. The paroccipital processes project backwards, and do not touch the bullæ.

11. The mastoid is very prominent.

12. The palate is not at all prolonged behind the molars.

13. The pterygoid fossa is small.

14. The coronoid process of the mandible is high and inclined backwards.

15. There is a short pollex (in *Hoplophoneus* at least.)

16. The hallux is well developed.

17. The ungual phalanges are retractile, and in *Hoplophoneus* are strongly arched and have wide bony laminæ at their bases.

18. The humerus has an epicondylar foramen.

19 and 20. Unknown.

21. $\underline{\text{P. 1}}$ and $\overline{\text{P. 2}}$ often developed.

22. There is often an $\overline{\text{M. 2}}$, but no $\underline{\text{M. 2}}$.

23. $\underline{\text{M. 1}}$ is transversely extended.

24. The antero-external cusp of $\underline{\text{P. 4}}$ is rudimentary or absent.

25. The talon of $\overline{\text{M. 1}}$ is much better developed than in the *Felidæ*.

26. The limbs are relatively short and the feet weak.

27. The postero-internal cusp of $\overline{\text{M. 1}}$ is often present.

28. The lower incisors form a straight row; the second in a line with the others.

29. The front of the jaw is not tapered, and the chin abruptly truncate.

31. Unknown.

The *Nimravidæ* differ from both *Viverridæ* and *Felidæ* in the following respects:—

(1.) The paroccipital process is not applied to the bulla.

(2.) The mastoid process is quite prominent.

(3.) The carotid canal is conspicuous.

4. The condylar foramen is not enclosed in the foramen lacerum posterius (as is also the case in *Viverra antiqua* and some of the lynxes).

5. Glenoid foramen large.

6. There is usually a large third trochanter on the femur.

7. The astragalus in some genera much flattened, and articulates with the cuboid.

These comparisons show that in the *Nimravidæ*, and more especially in *Dinictis*, there is a strange association of both feline and viverrine features, together with others, which are more primitive than those which occur in the living representatives of either of these families. In order, therefore, to understand the systematic relations of the extinct family, we must assume either that these animals are not related to the felines at all, but resemble them merely as the result of an independent and parallel development, or that the *Felidæ* and *Viverridæ* are related. In view of the numerous and extraordinary resemblances between the cats and the higher *Nimravidæ*, which no one has ever called in question, the weight of probability is strongly in favor of the second view—namely, that the cats are a highly specialized branch of the primitive group which also gave rise to the *Viverridæ*. If we admit the connection between the *Nimravidæ* and the *Felidæ*, that between the latter and the *Viverridæ* seems necessarily to follow.

With regard to the White River genera of this family, Schlosser has remarked as follows (No. 15, pp. 589–90): "Unter den Fleischfressern treffen wir hier zum ersten mal katzenähnliche Formen, *Drepanodon*, *Dinictis*, *Bunælurus* und *Hoplophoneus*, doch soll nur das Gebiss und der Schädel mit jenen der Katzen nähere Uebereinstimmung zeigen, das Skelet jedoch vielmehr an jenes von Hunden erinnern. Höchst wahrscheinlich handelt es sich hier um einen völlig erloschenen Formenkreis." These statements are due to a misunderstanding of my account. The skeleton of *Dinictis* and *Hoplophoneus* is not like that of the dogs, but it does resemble in many important respects, as does also the skull, that of the primitive dog-viverrine group, of which *Cynodictis* may be taken as a typical example. So numerous and important are the correspondences between the dentition, skull and skeleton of *Dinictis*, the lower viverrines and the ancestral dogs, that it seems impossible to avoid the conclusion that they are all very closely related.

Schlosser has not as yet discussed fully his reasons for separating the *Felidæ* so widely from the other Carnivora, and deriving them independently from the creodonts, not having reached that portion of his great work. Some hint of the grounds for his views may be gained from a recent short paper (No. 15, p. 596), where criticising Filhol's opinion that *Stenoplesictis*, *Proailurus*, etc., form the transition from *Cynodictis* to the cats, he says: "Dies ist jedoch wenig wahrscheinlich, da eine so weitgehende Umgestaltung unmöglich

sehr rasch erfolgen konnte, d. h. innerhalb des Zeitraums, welcher durch die Fauna der Phosphorite begrenzt erscheint; ausserdem sprechen auch anatomische Gründe gegen diese Annahme. Bei allen diesen Formen ist nämlich der zweite untere Schneidezahn wie bei der Gattung *Cynodictis* und den Hunden, Mardern und Zibethkatzen schon hinter den ersten und dritten gerückt, während die Schneidezähne bei den Katzen mit dem Kronenteil eine Reihe bilden, ferner erscheint der vordere Teil des Unterkiefers nicht abgestutzt wie bei den Katzen, sondern läuft spitz nach vorn zu, und ausserdem sind auch hier die Schlüsselbeine ganz wie bei allen Hunden, Mardern und Zibethkatzen verloren gegangen, während die Katzen noch deutliche Rudimente derselben aufzuweisen haben. Da aber die Nachkommen unmöglich in der einen oder andern Beziehung dem ursprünglichen Zustand näher stehen können, als ihre Ahnen, so wird die Filhol'sche Ansicht wenig haltbar erscheinen."

Though not wishing to defend Filhol's views, it seems to me that the anatomical objections which Schlosser urges against them are of no great weight. It seems quite clear that the slender, tapering, mandibular ramus is the original, primitive one; at least, it is well nigh universal among the creodonts, and it is difficult to see why the form which characterizes the feline lower jaw should not have been derived from the slender ramus. At all events, the hyenas, which Schlosser admits to be closely connected with the civets, have developed a mandible, which, in its anterior portion, is very like that of the cats, and in this respect *Cryptoprocta* is just intermediate between *Proailurus* and *Felis*—a slight change further in the same direction would reproduce the mandible of the cats.

Necessarily correlated with the shape of the mandible is the arrangement of the lower incisor series—here, again, it would appear that the *Felidæ* present, so far as the Carnivora are concerned—not the primary, but a modified condition, for in all of the creodonts in which the condition of the lower incisor series is known to me, the second one is either wanting, or has been pushed back of the first and third, just as in the dogs and civets. In this respect, also, *Hyæna* agrees with the cats, as do some, at least, of the bears, and it would appear to be a necessary consequence of the widening of the muzzle in the groups mentioned.

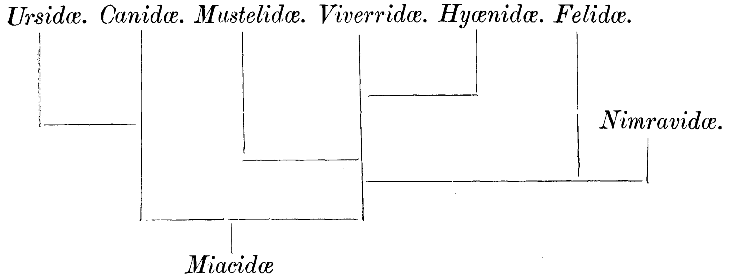
As regards the presence of clavicles in the cats, it need only be said that nothing is as yet certainly known as to their presence or absence in the early members of the various groups which now do not possess them.

It may not be fair to assume that these are Schlosser's chief reasons for excluding the *Felidæ* from the æluroids, as they are employed only against the derivation of that family from *Proailurus*, etc., but apparently they imply as much, especially when read in connection with other passages. Nor do his attempts to explain away the correspondences in the structure of the skull between the cats and the viverrines, appear to me much more successful, though lack of space forbids a discussion of them here.

No known group of creodonts can be selected as having any close relations to the cats. The *Oxyænas*, it is true, do exhibit certain surprising analogies with the recent family, but the analogy is confined to the teeth, and is only superficial, as the teeth which in the two groups look so much alike, are not homologous, and are developed in quite a different way. The lower sectorials of *Protopsalis*, for example, are very cat-like, but not so much so as those of *Cryptoprocta;* and the feet of the former genus, as well as those of *Oxyæna* itself, and *Hyænodon*, are curiously specialized in an entirely opposite sense from that which characterizes the cats.

Unless, therefore, we are prepared to regard the resemblances between the *Nimravidæ* and the *Felidæ* as merely analogical, which, to say the least, seems highly improbable, we must admit a connection between the latter family and the viverrines, since the *Nimravidæ* clearly show that they are not far removed from the primitive series, of which *Cynodictis* may be taken as a representative.

The following table will show the modifications in Schlosser's scheme, which seem to me to be necessary. The *Procyonidæ* are omitted, as we have as yet no information upon their history:—



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